Reliability process of long-term operated gas pipelines in difficult mining and geological conditions

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Abstract
The analysis of emergency risk starts with expert assessment of conditions and mechanisms of accidents on concrete components of gas transmission and formation of general idea about priority of certain actions concerning reliability increase. At the same time experts should be informed about accidents, taking place both on the object, and on the similar objects. Information on all service conditions of the considered object is also important.
Key words: FATIGUE, FLOOD, STRESS RAISER, WELDED JOINT, WELDED SEAM, GAS PIPELINE, STATIC LOAD, LOW-FREQUENCY LOAD

The problem of ensuring of high operational reliability of main pipelines (MP) is important for national economy of Ukraine as their considerable part is operated for a long time and has already depleted the standard resource. Stable work of MT and its high economical efficiency, first of all, depends on its technical condition. When estimating technical condition of the pipeline, the prominent place is held by reliable determination of strain-stress state (SSS) of its linear part as one of major factors on which depends the level of operational reliability of construction [1, 2].

During emergency (unsealing) of gas pipelines explosive gas comes to the surface under high pressure into atmosphere. At pressure decrease in the gas pipeline automatic devices for cranes closing are activated that turns over emergency division. Volume of gas reached the environment depends on the length and is blocked by automatic mechanisms of division and reaction time of block valves. Propagation distance of a cloud of explosive mix in the direction of wind is determined by empirical formula:

$$l = 25 \cdot \sqrt{\frac{M}{w}}\ , \text{m} \qquad (1)$$

where M – mass velocity of gas from damaged area of gas pipeline, kg/s; w– wind speed, m/s.

USA scientists faced more serious problem. Formula for determination of radius of potential impact (PIR - potential impact radius) is unusable in Willa Houston view. In particular, in regulating documents of the USA the formula for determination of potential impact radius looks as follows:

$$r = 0.69 \cdot D \cdot \sqrt{p}\ , \qquad (2)$$

where r – radius of potential effect, foot (1 foot = = 0.3048 m);

p – maximum working (operating) pressure, pounds per square inch (1 pound per square inch = = 6834.76 Pa);

D – outer diameter of gas pipeline, inches (1 inch= = 0.0254 m).

Edison Township, New Jersey, 4/23/94 TETCO – explosion of gas pipeline (36» pipe diameter, working pressure 975 pounds per square inch). Forecasted PIR is 775 feet (236.4 m). However, visually the radius of action is 1000 feet (304.8 m) (fig.1). 70 people were injured, 1500 people were evacuated, 9 placements were destroyed.

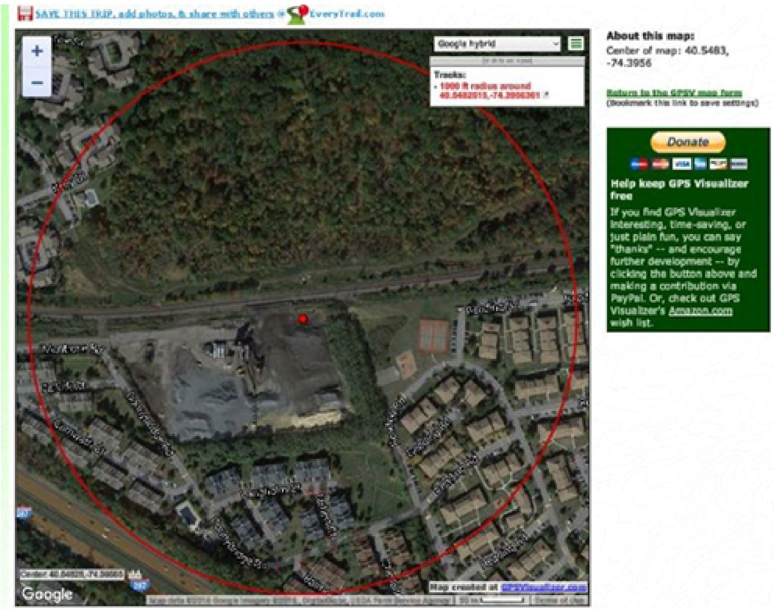

Figure 1. Accident on the gas pipeline Edison, the State of New Jersey, USA, 1994

In work [4] there suggested formula for evaluation of effective zone during failure of main gas pipeline along full cross-section:

$$r = 99 \cdot D \cdot \sqrt{p}\ , \qquad (3)$$

where: r – potential effect radius, m;

p – maximum working pressure, MPa;

D – outer diameter of gas pipeline, m.

Having applied formula 3 for calculation, according to the mentioned above data we obtained 234.7 m (770 feet). As one may see there is small inaccuracy.

On May 12, 2014 there occurred unsealing of aerial crossing of MG «Urengoy - Pomary - Uzhhorod» (4268.4 km.) through the river of Limnitsya. During investigation of pipe body there was revealed a handling mark of oval form with dimensions of 300*285 mm, depth 49 mm, in the center of handling mark there is a through crack with the length of 70 mm, crack extension – up to 4.0 mm at a distance of 2870 mm from 12 hours in the place of circular weld between the 2nd and 3rd segmented bends (along the gas flow) at the entrance of aerial crossing of MP "Urengoy-Pomary- Uzhgorod" through the river of Limnitsya. In the place of refusal there are no corrosion or other defects that is confirmed by data of in-line and visual inspections. The committee considers that the reason of failure is mechanical damage of pipeline from outside by strangers as a result of operation of explosive device of unknown design that led to formation of oval handling mark with through crack.

Figure 2. Aerial crossing of MP "Urengoy-Pomary- Uzhgorod" through the river of Limnitsa

Figure 3. Pipelines passing in one technological corridor and cross natural obstacles

Statistics shows that about 80% of accidents are followed by heavy fires and explosions. There appear sparks as a result of interaction of gas particles with metal and firm particles of the soil. As is seen from the figure 3, in the mountain area, in particular Ivano-Frankivsk and Transcarpathian Region, pipelines pass in one technological pipeline, cross natural and artificial obstacles.

For safe operation and reduction of losses during accidents, it is necessary to clearly establish and define the area of explosive influence. Let us analyze and calculate a zone of potential influence for gas pipelines, passing in parallel, in particular «Urengoy-Pomary- Uzhgorod» and «Progres».

Change of knocking zone value is represented in figures 4-6.

Simple burning can turn into explosion due to the speed of distribution of flame at its propagation across the relief and in forests.

Besides, at guillotine rupture of gas pipeline of high pressure there is distribution of metal pieces and fragments of pipes as during destruction of the pipeline energy of expansion of gas is spent for pipe deformation, its destruction, formation of primary and secondary splinters.

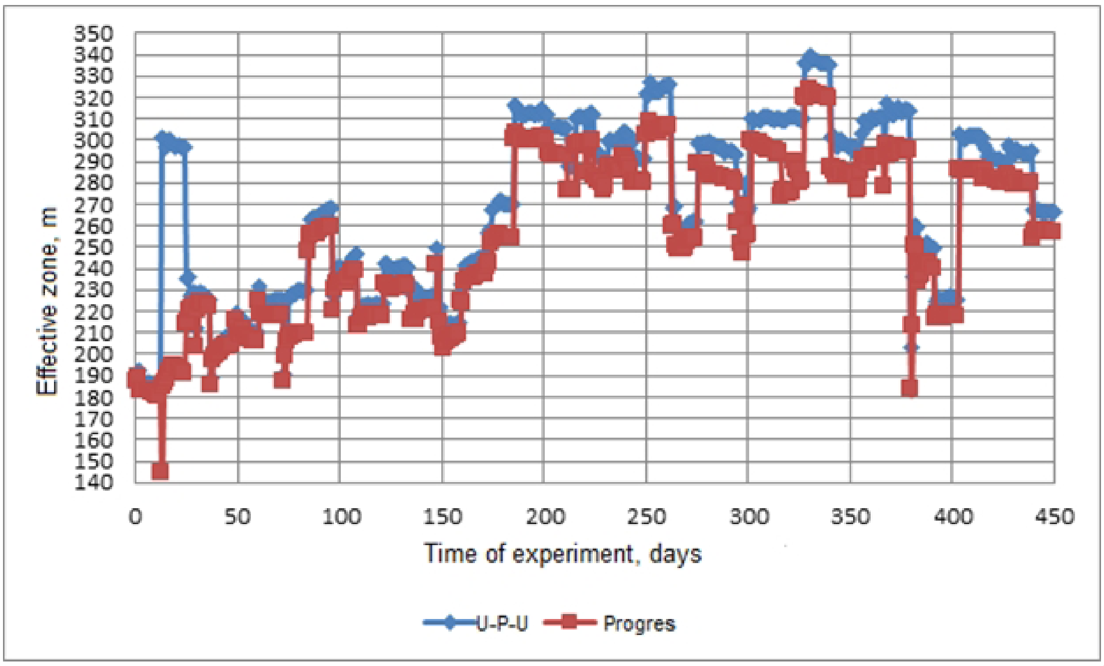

Figure 4. Radius of potential effect, in meters, that occurs in result of change of gas transportation mode (according to formula 1)

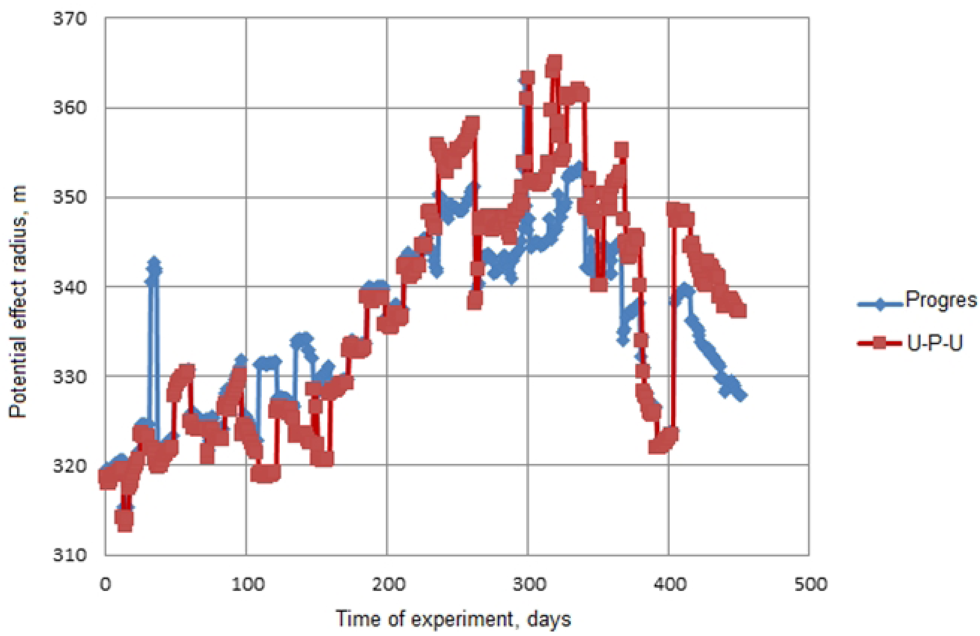

Figure 5. Radius of potential effect, in meters, that occurs in result of change of gas transportation mode (according to formula 2)

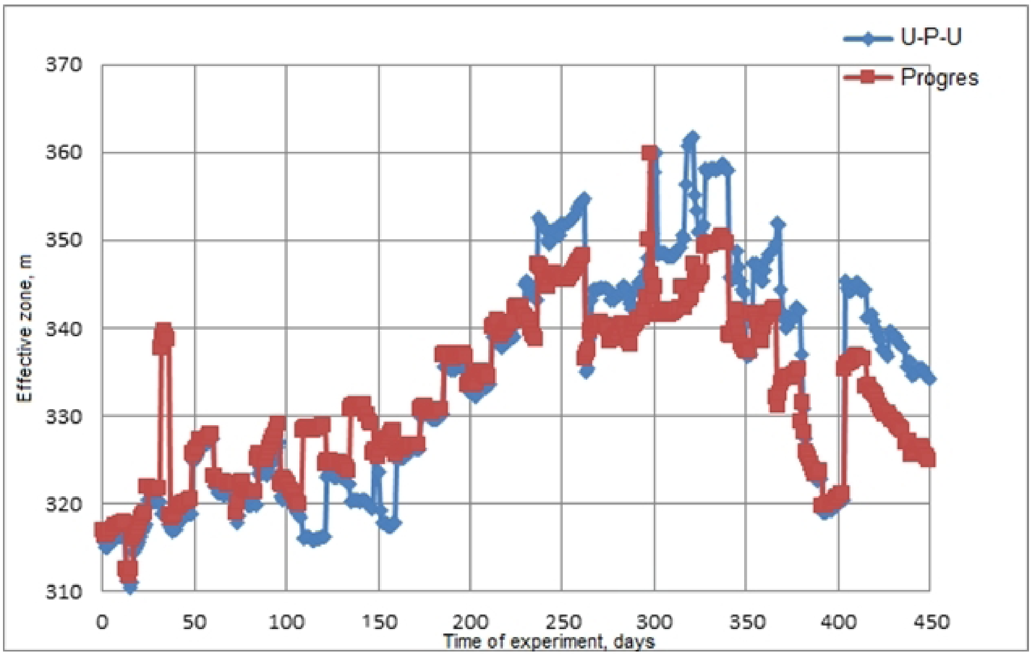

Figure 6. Radius of potential effect, in meters, that occurs in result of change of gas transportation mode (according to formula 3)

Conclusions

During researches the maximum value of knocking zone is 340 m, and minimum - 140 m. Effort variation factor is 162% that testifies to considerable nonuniformity of selection and consequently the modes of operation of gas pipeline. Change of knocking zone causes change of influence of operation of main pipelines on environment and therefore requires additional checking. Mass flow, which describes processes of origin of sharp amplitude oscillations of pipeline effective zones, dominates.

To increase the safety of operation of the main gas pipelines, it is necessary to analyze creation of security and safe zone towards the axis of pipeline construction. Taking into account the above-mentioned facts, it is possible to tell that correctly calculated and well balanced security zone as well as timely and good-quality engineering service of pipelines will considerably reduce losses and scales of accidents.

With respect to the available data, including explosions in the USA, for the pipelines passing in one technological corridor, private data on the value of radius of potential influence should be available.

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